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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/981,842	10/19/2001	Kenji Imanishi	011287	7067

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EXAMINER

BAUMEISTER, BRADLEY W

ART UNIT	PAPER NUMBER
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2815

DATE MAILED: 08/28/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/981,842

Applicant(s)

Imanishi

Examiner

B. William Baumeister

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136 (a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on Jul 14, 2003.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-18 and 21 is/are pending in the application.
- 4a) Of the above, claim(s) 4 and 13-15 is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-3, 5-12, 16-18, and 21 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claims _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
*See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).
a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☐ Notice of References Cited (PTO-892) 4) ☐ Interview Summary (PTO-413) Paper No(s). _____
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 5) ☐ Notice of Informal Patent Application (PTO-152)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s). _____ 6) ☐ Other: _____

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DETAILED ACTION

Claim Rejections - 35 USC § 102 and § 103

1. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

2. Claim 1 is rejected under 35 U.S.C. 102(b) as being anticipated by Ando et al. '168.

Ando discloses HEMTs having plural undoped InGaAs channel layers of In an Ga compositions (i.e., different bandgaps). Note, for example, the embodiment of FIGs 7A and 7B wherein a 50 angstrom "second channel" 63A supports a 25 angstrom "first channel" (channel of lowest bandgap) 63B and doped electron supply layer 43 on a buffered semi-insulating substrate. Other embodiments (such as FIGs 3 and 5 show that the "second channel" may be composed of multiple layers (e.g., 23A&B or 43A-C) that are positioned between the first channel and the substrate: i.e., that the second channel may be step graded.

a. While the embodiments depicted set forth the HEMT being formed on a GaAs substrate, the invention is not so limited. Rather, Ando expressly states that the respective layers of the 2DEG FETs may be replaced with other compound semiconductors to match various requirements (such as bandgap and lattice-constant requirements that were set forth in the Ando specification); Ando also expressly states that these alternative examples include an InAlAs/InGaAs [sic: InAlAs/InGaAs] compound system on an InP substrate. (Col., 23, lines 57-66).

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3. Claims 3, 5, 6 and 8 are rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Ando '168. As was stated above, Ando teaches all of the limitations of independent claim 1, including the generic recitation that one material system that may be employed for HEMTs grown on an InP substrate is InAlAs/InGaAs. While one skilled in the art would understand this disclosure to imply that in such a system InAlAs, in particular, would most likely be employed for the electron supply layer (because InAlAs has the largest band-gap of this material system) and relatively lower band-gap InGaAs-based compositions are employed for the channel layers, this disclosure does not expressly include the further description of whether the various channel layers of respective bandgap/composition are obtained by altering the In and Ga compositions of tertiary InGaAs (e.g., claim 8), or alternatively, by providing multiple In(AlGa)As channel layers with varying Al compositions (e.g., claim 3).

a. One skilled in the art understood at the time of the invention understood that these two recited means were the primary--if not only--conventional ways for making a multichannel region of distinct bandgaps out of an InAlAs/InGaAs system. Further, it was understood by the skilled artisans that the growth of tertiary InGaAs layers (Al=0) with differing In/Ga ratios provided the benefit of being easier to grow than quaternary In(GaAl)As, but has the drawback of being limited in the amount the In/Ga ratio (and therefore the bandgap) may be changed due to lattice-constant-mismatch issues. Conversely, the growth of quaternary In(GaAl)As provided the benefit of enabling the achievement of a larger range of compositional ratios (bandgaps) that are

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lattice-matched to InP, but possessed the drawback that quaternary compounds are more difficult to grow than were tertiary compounds.

The JP '934 reference (of which the present Applicant was one of the named inventors) and the Kohara '542 reference, both previously made of record, support the Examiner's position that it was conventionally known how to grow InAlAs/InGaAs tertiary and quaternary systems on InP that do not employ hybrid III-AsP alloys.

b. Thus, if Ando's disclosure--that an InAlAs/InGaAs system may be employed for InP substrate--is interpreted to including the implicit teaching that either conventional method of bandgap engineering may be employed, the claims are anticipated. Alternatively, if Ando is interpreted as only teaching the compositional varying of tertiary compounds (as was employed in the depicted GaAs-substrate based embodiments), then claim 8 (directed towards tertiary layers) would be anticipated and claim 3 (directed additionally towards quaternary layers) would not be anticipated, but would be obvious. As a second alternative, if Ando must be interpreted so narrowly as not suggesting either specific means with sufficient precision so as to anticipate either embodiment, neither claim 3 nor 8 would be anticipated, but both would be obvious in light of the disclosure.

c. If not anticipated, the claims would have been obvious because, as was stated above, the goal of providing composition-graded multi-layer channel with an InAlAs/InGaAs system was taught by Ando, and the two functionally equivalent, conventional methods of

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achieving this goal are by the stated methods: strained tertiaries providing the benefit of easier processing and lattice-matched quaternaries providing the benefit of improved lattice-matching.

d. Regarding claims 5 and 6, Ando expressly states channel thickness dimensions that are on the same order of magnitude as those claimed, but does not expressly state what the dimensions would be if the disclosed InAlAs/InGaAs system were employed. In light of the fact that Ando teaches the general parameters relating to the desirability of increasing the channel thickness and the restraints placed by lattice-mismatch issues, these particular thickness limitations may be viewed as being inherently or implicitly disclosed by the more general, express disclosure that an InAlAs/InGaAs system may alternatively be used. This is because one skilled in the art would have understood that the change in the material system would most likely dictate associated small alterations to these design parameters in order to also achieve the ultimate goals that are desired by Ando in an InGaAs system. Alternatively, the claims would at least have been obvious to one skilled in the art at the time of the invention as these limitations constitute the optimization of conventional design details, readily ascertainable by the skilled artisan through routine experimentation for the reasons set forth above.

4. Claim 2 is rejected under 35 U.S.C. 102(b) as anticipated by Ando '168 or, in the alternative, under 35 U.S.C. 103(a) as obvious over Ando '168 in view of JP '898 (previously made of record in IDS #4). As was explained above, Ando discloses the use of an InAlAs/InGaAs system for a graded-channel HEMT on InP but does not address the issue of

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higher energy electrons being spread into the second channel upon the application of higher electric fields or the resultant effect the second channel has on the impact ionization effect. Nonetheless, since the Ando invention sets forth the same multi-channeled structure (i.e., a second channel layer having an intermediate bandgap), the Ando structure must necessarily produce this same effect, and the claim is anticipated under the inherency doctrine.

a. Alternatively, assuming *arguendo* that the Ando structure would not necessarily produce the effect of the claimed limitation (e.g, if Applicant were able to show that it was possible to grow a second, intermediate bandgap channel layer according to Ando for the purposes described therein such that the dimensions of the second channel do not support a second bound electron state), the claims would nonetheless have been obvious over JP '898.

b. JP '898 teaches the same quantum physics concept as that of the present invention: to provide a second channel layer that accepts higher order (or hot) electrons under high electric field conditions for the purpose of suppressing the impact ionization effect. JP '898 does not anticipate the claims because JP '898 teaches that the second channel layer is III-P based whereas the present claims set forth that the second channel does not include P. Applicant acknowledges these teachings of JP '898 in the BACKGROUND section of the specification.

c. It would have been obvious to one of ordinary skill in the art at the time of the invention to have adjusted the second channel layer thickness of an InAlAs/InGaAs system HEMT made according to the teaching of Ando such that it would accept hot electrons under high electric fields for the purpose of suppressing the impact ionization effect as taught by JP '898.

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d. Alternatively, it would have been obvious to one of ordinary skill in the art at the time of the invention to have formed the JP '898 device with a second channel layer that is composed of an InAlAs/InGaAs system as taught by Ando instead of the JP '898 hybrid III-AsP system alloy for the purposes of simplifying manufacturing and reducing the manufacturing costs by not requiring the use of an additional P source.

5. Claims 3, 5-7, 10-12, 16, 18 and 21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ando '168 in view of JP '898 as applied to the claims above. As was stated above, Ando and JP '898 teach the general conditions of a multi-layer or graded channel InGaAlAs-based HEMT that supports hot electrons in the second channel. As such, the further dependent claims merely set forth obvious design details that would have been readily ascertainable to one skilled in the art through routine experimentation.

a. For example, claims 7, 10, 12 and 21 further set forth that the quaternary lattice-matched $\text{In}_{1-x}(\text{Al}_{1-z}\text{Ga}_z)_x\text{As}$ second channel layer (addressed above) more specifically has an Al concentration of $1-z = 0.05 \sim 0.5$, or a total Al concentration of $0.025 \sim 0.25$.¹

¹The Examiner notes for the record that because AlAs and GaAs have approximately the same lattice constant, lattice-matching $\text{In}_{1-x}(\text{Al}_{1-z}\text{Ga}_z)_x\text{As}$ to InP requires that the In concentration, $1-x$, be on the order of about 0.52 (see e.g., the present specification at page 16, lines 2-11). This fact--itself well known at the time of the invention--indicates that a z concentration of $0.05 \sim 0.5$ yields an ultimate $x * (1-z)$ Al concentration of $0.52 * (0.05 \sim 0.5)$, or roughly $0.025 \sim 0.25$.

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b. While Ando does not set forth any specific Al compositional ratios for an InAlAs/InGaAs system, given that it would have been obvious to have employed a quaternary lattice-matched scheme for the reasons set forth above, it would have been further obvious to one skilled in the art at the time of the invention to have set Ando's intermediate-bandgap, second channel layers (or a portion of a layer graded according to Ando--see e.g., col. 23, lines 52-56) to be within this recited range because Ando and JP '898 teach the general required conditions of lattice-matching and supporting hot electron states, so setting a second channel layer to satisfy this composition/bandgap limitation constitutes a mere optimization of design details since the ability for the second channel to support the hot electron is a function of the width and depth (composition) of the channel layers relative to each other and relative to the bandgap offsets of the surrounding buffer and electron supply layers, according to quantum particle-in-a-box theory. The calculation or determination of the optimal channel thicknesses (e.g., claims 5 and 6) and compositions (e.g., claims 7, 10 and 12) would be readily ascertainable by one skilled in the art of bandgap engineering and would be readily attainable through routine experimentation.

6. Claims 9 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over either Ando '168 or alternatively Ando/JP '898 as applied to the claims above, and further in view of Applicant's Prior Art admissions. Regardless of whether either of Ando or JP '898 teaches that the HEMT thereof may be etched to the buffer, Applicant acknowledges that it was known to etch HEMTs to the buffer layer (see e.g., BACKGROUND). It would have been obvious to one

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of ordinary skill in the art at the time of the invention to have etched an HEMT formed according to either of Ando or alternatively Ando/JP '898 down to the buffer for the purpose of providing carrier isolation between the HEMT and any other devices integrated on the InP substrate.

Response to Arguments

7. Applicant's arguments filed 7/14/2003 have been fully considered but they are not persuasive.

a. Applicant argues that in contradistinction to Ando, the lowest-energy-level channel of the present invention is provided next to the electron-supply layer and therefore produces a larger mutual conductance (REMARKS, page 8). This argument is ^{NOT} persuasive because the claims do not require that the first channel be in contact with the electron supply layer.

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b. Applicant argues that JP '898 teaches the inclusion P in the channel layer, whereas the present claims preclude the presence of P (REMARKS, page 9). This argument is not convincing because rejection was based on Ando (teaching a P-free InAlAs/InGaAs system) or alternatively on Ando in view of JP '898. As such, the argument that JP '898 may not teach a channel that is free of phosphorus does not address the fact that Ando does teach such a composition.

c. Applicant argues that Ando does not teach the specific Al concentration set forth in various dependent claims (REMARKS pages 9-10). This argument is not persuasive because the previous rejection, repeated hereinabove, acknowledged that Ando does not expressly recite

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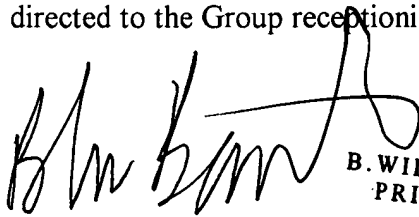
this composition, and the claim was therefore rejected as obvious over Ando in view of JP '898.

The argument does not address the combination of the references' teachings.

d. Applicant arguments with respect to the lattice-matching of the layers (REMARKS, page 10) was addressed in the previous Office Action and was restated hereinabove (see e.g., paragraph 5 of the present Office Action).

INFORMATION ON HOW TO CONTACT THE USPTO

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to the examiner, **B. William Baumeister**, at (703) 306-9165. The examiner can normally be reached Monday through Friday, 8:30 a.m. to 5:00 p.m. If the Examiner is not available, the Examiner's supervisor, Mr. Eddie Lee, can be reached at (703) 308-1690. Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Group receptionist whose telephone number is (703) 308-0956.



B. WILLIAM BAUMEISTER
PRIMARY EXAMINER

B. William Baumeister

Primary Examiner, Art Unit 2815

August 26, 2003